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Section H

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PROGRESS REPORT

PLANT STUDIES

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L. Jacobson and R. Overstreet

December 18, 1944

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THE FIXATION AND ABSORPTION OF FISSION PRODUCTS BY PLANTS

INTRODUCTION

Preliminary experiments conducted in this laboratory (1) indicate that most of the fission products may be firmly fixed on soil. The purpose of the work to be reported has been to determine whether or not radio elements so fixed are available to plants.

The accumulated information regarding the absorption of various elements by plants from soil strongly suggests that all elements are taken up to some degree when present in the soil in macro-amounts. It is of interest here to note that as much as 2.3 gms of yttrium per kilogram dry weight has been found in the leaves of hickory trees growing in yttrium soil (2). On the other hand, no published information exists as to whether elements in extremely small amounts (i.e. tracer amounts) are available to plants from either culture solutions or soils.

The test plants selected were three-weeks old barley plants. This plant was chosen because its method of culture has been well standardized (3). Plants so grown acquire the ability of absorbing inorganic nutrients quite readily.

These plants were exposed to radio-elements in two different ways. First, the plants were immersed for 24 hours in suspensions of purified Wyoming bentonite to which had been added the desired radio-element. Second, the plants were placed in nutrient solutions for a period of three weeks. The radio-element was added directly to the solution. It was not considered advisable to conduct the clay experiments for longer periods than 24 hours owing to the absence of the necessary nutrients. Had nutrient salts been added the clay would have flocculated and settled away from the root zone.

In order to obtain information supplementary to that given by the plant experiments, an examination was made of active algae collected from the settling basin.

PROCEDURE

Ca bentonite suspensions were prepared as follows: A 2% suspension of electro-dialyzed Wyoming bentonite was adjusted to pH 5.5 with saturated $\text{Ca}(\text{OH})_2$ solution. Aliquots of the resulting Ca bentonite suspension were diluted with distilled water to a concentration of 100 mgms per liter. Following this, the radio-element was added in an amount corresponding to 10 microcuries per liter.

In each case, six barley plants were placed in a quart jar containing 850 ml of the suspension. The suspension was continuously aerated by means of compressed air. Three jars of plants were set up for each element. The radio-elements were Y, Ce, Zr+Cb, and Sr. Following the 24 hour absorption period, the tops were removed from the plants and the roots were dried at 100°C and suitable aliquots counted. Portions of the initial suspensions were centrifuged in a McBain type spinning top centrifuge. The activity of the supernatant liquid was compared with that of the initial suspension. These results, as well as the uptake of activity by barley plants from clay suspensions are given in Table I.

TABLE I

<u>Elements</u>	<u>% Initially Fixed on Clay</u>	<u>Activity Taken Up by Roots-% Dose</u>	<u>* Activity Translocated to Leaves -% Dose</u>
Y	98.8	27.7	0.104
Ce	94.3	27.1	0.0303
Zr-Cb	98.5	33.5	0.00310
Sr	60.4	10.7	1.60

Average fresh weight of leaves from six plants = 1.75g; dry weight = 0.370g.

Average fresh weight of roots from six plants = 7.12g; dry weight = 0.595g.

* An assay of the activity in the leaves showed the absence of radioactive impurities.

In the above experiment the clay concentration was 100 mgms per liter. In order to determine the effect of varying clay concentration on the fixation of activity by roots, the following experiment was performed. Two weeks old barley plants were immersed for 24 hours in a series of clay suspensions. Each suspension contained 10 microcuries of Y. The clay concentration of the suspensions varied from ~25 to 500 mgms per liter. In each case, six plants were used for 850 ml of suspension and each concentration was done in triplicate. Following the immersion period, the roots were separated from the tops, thoroughly washed, dried and counted. The results are given in Table II and plotted graphically in Figure I.

TABLE II

<u>Conc. of Clay mgms/liter</u>	<u>Y Activity Taken Up by Roots-% of Dose</u>
28.7	31.4
115.1	14.5
287.5	8.32
575.0	6.00

Average fresh weight of roots from six plants = 3.73g

Average dry weight = 0.205g.

In addition to the clay experiments, similar experiments were carried out with pure culture solutions containing the radio-elements. The culture solution had the following composition: KNO_3 - .0025M; $\text{Ca}(\text{NO}_3)_2$ - .0025M; MgSO_4 - .001M; KH_2PO_4 - .0005M, and Fe-3ppm; B-0.5ppm; Mn-0.5ppm; Zn-0.05ppm; Cu-0.04ppm; and Mo-0.01ppm. Six plants were placed in 850 ml of continuously aerated solution to which the radio-element had been added. The duration of the experiment was 21 days. Each treatment was performed in triplicate. The leaves and roots were treated as previously described. The results are given in Table III.

TABLE III

<u>Element</u>	<u>Activity Taken Up by Roots-% Dose</u>	<u>Activity Translocated to Leaves-% Dose</u>
Y	43.8	.0707
Ce	44.5	.0360
Zr+Cb	43.4	.00932
Sr	11.5	11.3

Average fresh weight of leaves from six plants = 14.0g; Dry weight = 1.64g.
Average fresh weight of roots from six plants = 11.7g; Dry weight = .660

A sample of algae from the settling basin at X-10 was collected in October 1944. The algae was washed in distilled water until it appeared to be free from clay. The activity of the dried material was found to be approximately 6 μ c per gm. An aliquot of the algae was assayed for its radioactive composition. The results are given in Table IV.

TABLE IV

<u>Element</u>	<u>%(Calculated to zero thickness)</u>
Ba+Sr	1.8
Y+Pr	1.4
Zr+Cb	61.6
Ru+Te	12.9
Cs	1.5
Ce	20.8

DISCUSSION

In the case of the test plants selected and under the conditions of the experiments, very large fractions of the initial doses of Y, Cr, Zr+Cb, and Sr are either fixed or absorbed by the plants. For each element, activity was found in the leaves as a result of absorption and translocation. The roots were in all cases relatively very active.

Of the elements investigated, Sr is by far the most readily absorbed and translocated. The other elements fall in the following order: Y, Ce, Zr+Cb. A comparison of the results of the 24 hours period of the clay experiments with those of the three week period of the culture solution experiments indicates that with the exception of Sr, the radio-elements when adsorbed on suspended clay particles are more readily accessible for absorption and translocation by the plant. The character of the culture solution is such that Y, Ce, and Zr+Cb are probably precipitated within a short time on the roots, walls, etc. in a form non-available for absorption by plants. Sr, on the other hand, remains largely in solution as would be expected and is readily available for absorption.

The observed order of the absorption and translocation of these elements cannot be correlated with their degrees of fixation on the clay. This is clearly evidenced by the differences in behavior of Y and Ce. Y is more strongly fixed

on clay than Cs, yet is found in greater amounts in the leaves. Differences of this nature are due to the selective absorption properties of plants.

The rate of accumulation of the radio-elements in the leaves by plants from natural soil might be expected to be of the same order as that observed for plants in clay suspensions. While it is true that the amount accumulated in 24 hours is not large, nevertheless the process will be continuous throughout the growth period of the plant. Thus in the life cycle of a plant, considerable quantities of activity may be involved.

The nature of the large fixation of the activity by the roots is as yet unelucidated. The activity is not the result of clay adhering to the roots since essentially all of the added clay was recovered from the solution even when as much as 35% of the dose was fixed on the roots.

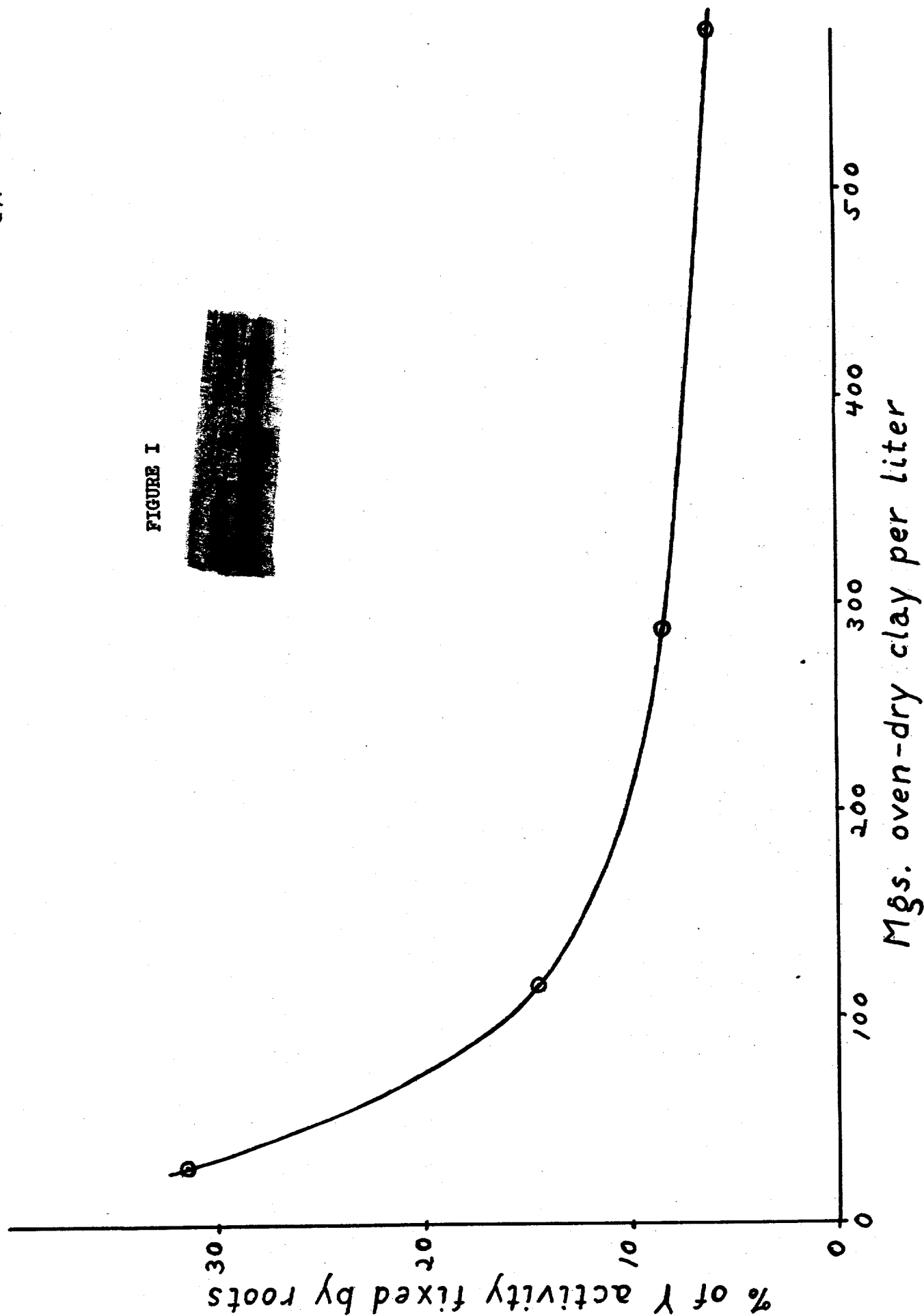
Since the amounts of soluble activities in equilibrium with active clay suspensions of Y, Ce, and Zr+Cb are very small compared to the amounts on the roots, there must necessarily have been a release of activity from the clay particles to the roots. Thus for these elements, roots can compete successfully with clay particles. In harmony with this idea, the data of Figure 1 show that with increasing clay concentration, the competition becomes less favorable for the roots. On the other hand, it is doubtful that even in soils, the clay content would be of such magnitude that no activity would be fixed by the roots.

Extensive studies have shown that many fresh water algae are similar to roots in their behavior towards mineral nutrients. Judging from the assay of the algae collected, it would appear that the same phenomena observed with roots are operative here. It is of interest to note in this connection, that the radioactive composition of the algae is not very different from that previously reported for the active clay. (4)

In conclusion it can be stated that an agriculturally important plant species has been observed to possess a very marked ability for the fixation of those elements which constitute a major portion of the fission activity, even when tracer amounts of the elements are initially adsorbed on clay particles. It should be emphasized that generalizations made from the observations reported here as to the behavior of barley in the natural soil and as to the behavior of other plant species in the natural soil are subject to modification. Nevertheless, it must be conceded that experiments made so far strongly support the conclusion that the release of fission activity to soils may constitute a serious problem in so far as plants growing on these soils are concerned. An accurate estimation of the consequences of releasing fission activity to soils will require much more experimentation.

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FIGURE I



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